1 Final publishable summary report

1.1 Executive summary

BIO-PROTECT is a fast-alert, easy-to-use device to be applied for detection and identification of airborne bacteria, spores, viruses and toxins. Its first responder technology is based on bioaerosol detection by fluorescence, scattering and background aerosol measurement. Subsequently to the detection of suspicious material the bio-agents will undergo concentration and preparation steps which are followed by ionisation of air flow and a two-fold analysis of the spectrum of relative speed of passage, which, in turns, enables identification of harmful biological agents.

The project activities can be broken down into 8 main areas:

- Development of the basic techniques and devices
- Measurement campaign for the proof of concept
- Parameter optimisation (improvement of techniques and devices)
- Consolidation of the single components
- Development of an appropriate control and evaluation software
- End User requirements
- Extended measurement campaign and field tests
- Exploitation

The Bio-Protect device is composed of four main sub-assemblies (responsible partner):

1) Bio aerosol detector/ Particle size analyzer (Environics)
2) Particle collector (CEA Leti)
3) Pre-Treatment Unit (CTECH)
4) GC-IMS (Environics-IUT)

In addition to these the device also includes Control electronics and software.

During the project two prototype devices were built and tested. The design of the Device in terms of mechanics, hardware (HW) and software (SW) is explained in detail in the deliverable D4.11 entitled ***Design of Device***. The 1st device prototype (Device1) was built based on the design described in that document and additional information can also be found in deliverable D4.21 entitled ***Test version of the 1st device***. During the assembly and the testing phases of Device1 some minor improvements were noticed, mostly in mechanics design. These changes in design were implemented within the 2nd prototype (Device2) and are described in the D4.31 ***Test version of 2nd device***.

The technological readiness level (TRL) of the device achieved during the project is TRL 7: “system prototype is demonstrated in operational environment”. Within the project the prototype was used, in other words, demonstrated in operational environments:

i) indoors at Aalborg University in Copenhagen during AAU tests,
ii) in laboratory environment at RKI in the bio-aerosol chamber with real bio agents,
iii) in Techonin in Czech Republic on 7-10th October 2013.

The execution of the field test in Techonin (Czech Republic) was handled by two different teams. Czech Republic was represented with four members from CBRN reconnaissance teams of Population Protection Institute (Fire Rescue Service DG) and regional Fire Rescue Service detection laboratories. The German team was composed of three team members from the Analytical Task Force (a CBRN reconnaissance team from the Mannheim Fire Brigade).

However, the Device was not tested in all possible environments during the project because of limited time in the project.
It was noticed during the project while assembling, using and testing the device that further development of some parts and components are needed to improve the device and to reach marketable level. In general the device must be developed to be more robust and reliable.

1.2 Project context and objectives

The malevolent use of Anthrax spores on civilians has shown the necessity to protect citizens from criminal use of biological agents. Detecting pathogenous bacteria (including spores), viruses and toxins has to be accomplished by triggering short-term alarm and identification of the type of threat.

The concept of BIO-PROTECT project is to develop a fast-alert, easy-to-use device to be applied for detection and identification of airborne bacteria, spores, viruses and toxins. The developed technology is based on bioaerosol detection by fluorescence, scattering and background aerosol measurement followed by ionisation of air flow and analysis of the spectrum of relative speed of passage, which, in turns, enables identification of harmful biological agents.

The overall objective of the project is to develop a **compact, autonomous sensing system for detection and identification of biological agents**. Its primary purpose is to provide law enforcement officers or security personnel with means of fast-alert of bio-aggression in buildings as well as in outdoor crowd concentrations.

The device incorporates functions of sample collection, detection, analysis, signal processing and readout on the instrument. The system includes high sensitivity and selective miniaturised spectrometric sensor for fast detection. It targets microorganisms and viruses which are capable of severely taking ill or killing mammals. These are:

- agents for potential application in terrorist attacks (e.g. “dirty dozen” agents)
- accidental release of microorganisms and toxins

The Bio-Protect project involves the development and adaptation of peripheral devices as well as the advancement of software for control, analysis and interpretation. The system shall provide field workers with features for cognition of spores and bacteria; a technological breakthrough is needed for the fingerprinting of viruses and toxins.

The main development areas are particle enrichment and pre-treatment (e.g. pyrolysis) as well as the identification of viruses and toxins. Since amino-acids have been shown to be easily detected by IMS, biological toxins and viral coating proteins can as well be detected. Another focus of the project is improvement and integration of a bioaerosol detector to operate as a triggering unit to the pyrolysis-GC-IMS and the automation of the whole system. Real-time detection of harmful bioaerosols is a crucial step in the whole process of crisis management: it enables timely warning, protection and further identification of the released agents to minimize the casualties by initiating correct medical treatment.

Environics has been involved in the development of an advanced bioaerosol detector that is capable of monitoring ambient air for the presence of potentially harmful airborne biological particles. The device combines UV fluorescence and scattering based detection method with a unique background aerosol measurement technique that improves elimination of false alarms. In Bio-Protect, the bioaerosol detector is modified to form a compact and robust device to complete the pyrolysis-IMS-GC in the detect-to-warn-and-identify concept.

The detect-to-warn-and-identify concept will not supersede the deployment of HazMat teams and the confirmation in a laboratory, but it will provide instant knowledge about the type of threat. This, in turn, will lead to specific effective countermeasures. When connected to building air conditionning systems, for instance, the device with detection and identification capabilities shall provide constant monitoring of the environment.

Technological objectives

1. Development of a **bio-agent detection system** based on a GC-IMS (Gas Chromatograph - Ion Mobility Spectrometry) instrument able to identify and separate extremely small amounts of a wide range of organic molecules resulting of heat-decomposed organic matter.

2. Integration of a **particle size analyser** which constantly monitors the ambient air, thus triggering a measurement if a sudden change in particle size and/or density occurs.

3. Improvement and integration of a continuously operating **bioaerosol detector** measuring fluorescence, scattering and background aerosol properties to detect presence of potentially harmful biological agents in ambient air and to trigger further identification

4. Research and development of a **combined pre-concentration and pyrolysis unit** for use with a GC-IMS,that can separate all types of bio-agents from aerosols. The target is to detect bio-agent concentrations likely to infect or intoxicate.

5. Development of **pattern analysis software** for the interpretation of the acquired spectra, thereby identifying bio-agents and distinguishing them from background bacteria.

6. Generation of a **database** whose alpha version contains at least the fingerprint-data of the following model-agents (and their avirulent or non-toxic surrogates respectively) for assay-configuration:
   - **Bacteria:** *Bacillus anthracis* (spores), *Francisella tularensis* (vegetative bacteria)
   - **Toxins:** Ricin, staphylococcal enterotoxin B (SEB)
   - **Viruses:** Orthopox viruses, Filoviridae

   The scope of Bio-Protect includes constant extension and upgrading of the database, leading to the delivery of a marketable version with an extended scope (to be specified during the project).

7. Development of a **control unit** operated by a touch screen also displaying the discrete results and development of a PC user interface for testing and evaluation of the device.

8. **Design** of the device and **integration** of the components.

1.3 Main S&T results/foregrounds

The BIO-PROTECT device integrates several sub-assemblies, which have been redesigned and some of them miniaturised:

- A particle size analyser which constantly monitors the ambient air, thus triggering a measurement if a sudden change in particle size and/or density occurs.
- An electrostatic air sampler, capable of collecting submicron particles
- A combined pre-concentration and pyrolysis unit for sample pre-treatment
- A GC-IMS which can separate and identify very small amounts of a wide range of molecules.

Hardware components have also been assembled and tested, as well as a combined battery pack and AC power. Major parts of the software have been created, and include a user interface which is structurally displayed, but requires further development and finalisation.

In addition, pattern analysis software has been developed for the interpretation of the acquired spectra, thereby identifying bio-agents and distinguishing them from background bacteria. Thus a database of several model-agents including bacteria, spores, toxins and viruses has been generated. Constant extension and upgrading of the database was planned, in order to lead to the delivery of a marketable version with an extended scope.

1.3.1 WP1 Development & Optimisation

Task 1.1 Development of pre-treatment unit

- **Conception and construction of the particle collector and concentrator**

A new concept was developed at CEA-Leti for an airborne particle collector, capable of capturing efficiently and independently of size, any kind of aerosol ranging from a few tens of nanometres to a few microns. The collection device consists in a standard electrostatic precipitator, where the particles are charged via an electrical corona discharge and collected subsequently due to the electrostatic forces. In addition, a small amount of water vapour is injected in the incoming air flow in order to improve the collection rate.

The preliminary model developed in CEA was an air sampler designed to treat 30 LPM of air. In order to reach the project specifications, the module sizing was revised: the chamber diameter was increased to maintain the properties of the flow and more generally all parameters were revised to maintain ratios between physical phenomena.
Since the flow rate evolution is small, the different design scenarios (based on different sizing criteria) are small.

In addition, a modular approach was chosen for the construction of the control box:
The developed module built as a demonstrator, the air sampler is then controlled by its own control box which will receive a trigger from the bioaerosol detector. This control box integrates a motherboard and all electrical components required to make the air sampler work. It may be later replaced by either the bioaerosol detector controller or any other controller.
The controller drives the air sampler in a sequence of well-defined tasks:

1. Capture of the airborne particles
2. Transfer of the sample to the next module
3. Cleaning of the collector chamber

- **Conception and construction of the pyrolysis unit**

For technical reasons the Ion Mobility Spectrometer (IMS) is not able to measure molecules with a size above 2 kDa, hence using the IMS it is impossible to measure complex proteins, viruses or microorganisms on the whole. But it is possible to break these complex structures down into smaller molecules.
Two methods were implemented and compared: thermal and electrical.

a) **Thermal method**

Three different approaches for the conception and construction of the pyrolysis unit (thermal method) have been chosen to evaluate the best possibility of breaking down complex structures, and one in particular is described below:

- *Development of a flow-through pyrolysis unit*

The idea was to build a pyrolysis unit which is constantly flushed when it is not in operation. As soon as the trigger signal is given the wire spiral is heated thus pyrolysing particles present in the air stream (or particle suspension passed from the particle collector and concentrator) while the resulting compounds are subsequently passed into the GC-IMS.
The flow-through pyrolysis unit consists of an Aluminium hollow piece, which incorporates a wire spiral made of Platinum as well as a hole which fits to the inlet of the GC-IMS. The wire spiral serves as heated filament whose electric connectors are lead through the hollow piece. An electrical current of about 2 Ampere causes the annealing of the heated filament. This annealing in turn causes pyrolysis of particles present in the air flow.

b) **Electrical method**

An alternate method has been tested, with different approaches of stressing microorganisms with electricity to break down their complex structures into compounds which can be measured by the IMS.

To ensure that the electric pyrolysis method generates compounds which can be measured by the IMS, an IMS from IUT was transferred to C-Tech and coupled to the pyrolysis units to be tested (coupling an IMS is the same as coupling a GC-IMS).

The key challenge was to provide a dry sample stream of analytes at sufficient concentration that can be detected with the IMS. To achieve this, combination of methods may be necessary.
In the early phase of the project, different attempts were performed and revealed some technical problems. A potential solution consisted in incorporating an ultrasonic atomiser coupled to a diffusion dryer membrane cell between the pre-treatment unit and the IMS. A further modification was also required in order to prevent condensation of the fine water droplets in the transfer lines.

- Pyrolysis/dryer

Because of the uncertainty of generating sufficient analytes using an electro-treatment method, work was also carried out to complement the direct pyrolysis methods being investigated by IUT. This is a ”hybrid” approach to the problem. Two possible configurations have been considered using the atomisation approach with the atomised sample passing through a hot zone to simultaneously evaporate the water and pyrolyse the sample

and a second concept using direct pyrolysis of the sample injected into a hot zone. Both concepts can be coupled to the diffusion dryer to remove the water vapour before analysis using the IMS, or in the direct pyrolyser case, there is the option of preheating the sample and providing a bleed stream to vent the water vapour before flash heating the sample to high temperature.
The three approaches were developed and are summarised in Figure 1. For each solution an experimental rig has been built.

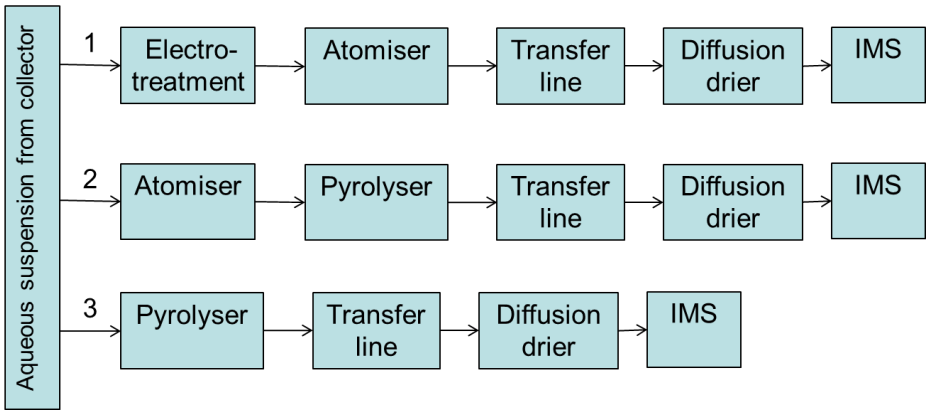


Figure 1: Potential configurations for pre-treatment modules

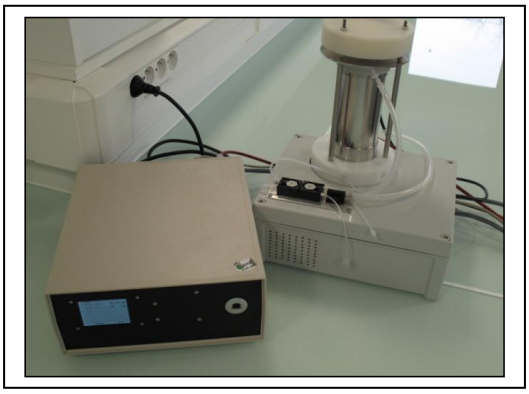
The required system needed to vaporize the collected aqueous sample in order to provide gaseous materials which can be transferred to the GC-IMS detector. The vaporized sample provides ultra-low concentrations of specific marker compounds present in the different bio-agents which can then be detected and differentiated by the GC-IMS detector and analysis software. Because the collected biosample is in an aqueous suspension, the high dilution factor and the large volume of water present in the collected sample presented a significant technical challenge. In the investigation, it was found to be critical to remove the excessive amounts of water present because its presence greatly reduces the IMS sensitivity and increases the service requirement of the detector due to the rapid exhaustion of the internal drying agent. A method was therefore needed to remove or reduce the amount of water from the collected sample, without loss of analytes and then to vapourise the analytes into the GC-IMS.

Work on approaches 1 and 2 (Figure 1) showed that the methods did not provide sufficient analytes for the detection by the GC-IMS and excessive water vapour was produced which could not be effectively removed by the diffusion driers. Work on these approaches was therefore stopped and effort concentrated on method 3, direct pyrolysis.

Task 1.2 Parameter optimisation

- **Technical Parameter optimisation of the pre-treatment unit**
  - Optimisation of the technical parameters of the air sampler

CEA built a second air sampler shown on the figure below.



This second prototype is a copy of the first one but it integrates some new features:

- a new electronic and an updated firmware to be controlled by a remote computer via an USB cable.
- a calibrated differential pressure sensor for controlling the flow rate.

Next, the air sampler efficiency to capture airborne particles was measured. Results were similar to the results obtained with the first prototype. The prototype was then sent to the Robert Koch Institute for the evaluation of the biological capture efficiency and its optimization.
Meanwhile a manuscript was written in collaboration with the team of the Robert-Koch-Institute to communicate on this work:

design, test and optimization of a new electrostatic sampler for concentrating biological aerosol particles.

- Optimisation of the technical parameters of the pyrolysis units

Extensive work was carried out to deliver a method of pre-treatment of the (sampled) biological agents in order to detect them by the highly sensitive GC-IMS detector developed by Environics-IUT. In the second period, three technical approaches were further developed as potential methods for the pretreatment of the "bio-agents" sampled from air using the CEA electrostatic collector.

Work on the pyrolysis method using the diffusion drier was successful, but it was found that the large quantities of water vapour generated caused significant problems due to condensation in the transfer lines and rapid exhaustion of the drying medium used in the diffusion drier. To circumvent these problems a modification of the pyrolyser was also developed based on a system of two way microvalves and a heated valve block. This technical solution was found to be highly effective and detection of the analytes was possible. Based on this technical solution, it was decided to manufacture two prototype pretreatment units, one based on the pyrolyser with diffusion drier and one based on the valve unit. Heated transfer zones and controllers were included in the design. The developed pre-treatment modules were transferred to RKI for testing. The valve version showed to be highly effective for generating analytes detectable by the GC-IMS at extremely low levels. The technique has also shown that different types of bio-agents could be differentiated including bacteria and spores. However, the challenging nature of the technical targets outlined above and the need to design, build and test the different potential solutions, required considerably more time than was originally planned in the project, resulting in a delay in developing the selected process.
During the testing of the sample collector, pre-treatment and GC-IMS units at RKI, an unforeseen technical issue occurred. It was found that the quartz wool packing used in the pyrolyser module caused problems with memory effects and generation of contamination peaks. Incomplete pyrolysis of the biomaterials in the wool resulted in retained analytes which provided a background contamination "reservoir" in the pyrolysis tube which were then eluted in subsequent analysis cycles. The presence of the contaminant peaks prevented RKI from carrying out the necessary tests needed to generate the library of bio-agents. Thus further work was carried out at CTECH in order to identify an alternative matrix for the pyrolysis tube. Alternative quartz materials were investigated having longer fibre length and larger fibre diameters, however, it was found that the low thermal conductivity of the wool was the main problem and the alternative materials did not provide any significant improvement over the one currently used in the pyrolyser prototype. Work was therefore carried out on metal matrix materials in order to provide better thermal conductivity.
Matrix materials investigated were:

- Stainless steel "cloth"
- Nickel metal mesh
- Nickel metal foam)

Several packing options of the materials were investigated including loose pack, strips and spiral wound. After a number of trials, thermal cycling of the pyrolyser tubes showed that the metal packed tubes gave very rapid heating response with very little or no retention and were found to be heated to the pyrolysis temperature range 600-700°C faster than when using the silica wool packing. No degradation of the packing materials was observed after repeated cycling at 700°C over 20 cycles.
Based on the positive results obtained, an open weave, stainless steel cloth was found to give the best performance in terms of rapid heating and stability. Test pyrolyser tubes were prepared and supplied to RKI for testing on actual bio-samples using the BIO-IMS. In order to allow better retention of the metal matrix in the tube, a new tubes design which included small indentations to prevent the metal matrix from slipping was made and these were successfully supplied to RKI. Final modifications to the design were discussed with ENIT for the miniaturisation of the pyrolyser unit and a new smaller pyrolyser tube was developed and was supplied for the Bio-Protect prototype unit.

Task 1.3 Modification of a bioaerosol detector

In the WP1, Environics has been involved in the evaluation and modification of a bioaerosol detector version that has been designed previously to detect concentrated releases of potentially harmful airborne biological agents to give early warning for a possible biothreat case.

The main issues have been to determine, if there was a real need for integrating a background aerosol measurement unit and additional concentration stages to the system and further development of the alarm algorithm.

Data from recent measurement campaigns were used for adjustment of the alarm algorithm and further SW/HW and mechanical design of the bioaerosol detector. Work was spent on further development of the alarm algorithm and the mechanics and HW/SW design. As a result, an improved robust bioaerosol detector in a standard enclosure for fixed installations like building and area CBRN monitoring applications and a portable bioaerosol detector inside a Pelican case were designed.

- **Miniaturisation and integration of a background aerosol detection unit**

Task 1.3 included the following actions in improving the existing bioaerosol detector for fixed installations, and for creating a portable version of the bioaerosol detector with space reservation for additional devices to be integrated into the end-product:

- Development of improved embedded system software for measurement, system level functions and communication
- Design of embedded system hardware
- Revision of the mechanical design of the bioaerosol detector for mobile use
- Development of intelligent high power and high capacity rechargeable power supply unit (PSU) including hardware design, embedded software design and system testing.
- Since there are no suitable commercial power supplies available on market, the PSU was designed for these special needs.
- Background measurement campaigns and indoor and outdoor testing with biological simulants and analysis of the gathered data were carried out
- The preliminary alarm algorithm and its implementation were studied and the data analysis software was improved for fluent analysis of the data gathered from the background measurement and indoor/outdoor testing. The data were used for further alarm algorithm development and adjustment of the different parameters of the algorithm.

- **Modifications required for modular integration of a pyrolysis-GC-IMS unit to the detector**

The bio aerosol detector was modified in a way that it can act as a slave unit to a control unit. This control unit in turn will be able to recognize the possible trigger signals given by the aerosol detector. These signals can be remitted to the air sampler thus starting the measurement of the pyrolysis-GC-IMS unit.

- **Construction of a technical prototype of the modified bio aerosol detector**

    - A bioaerosol detector for fixed/mobile detection systems

The standard bioaerosol detector designed for fixed and mobile biological detection systems was built inside a polyester painted steel enclosure. The enclosure was designed to be mounted vertically on the wall or with a special mounting rack to enhance shock and vibration tolerance in mobile applications like vehicles. A PC-UIP or dedicated system software applied in the monitoring systems works as a user interface for the device.

For the primary detection, the air pumps of the device draw continuously particle-laden air through a prefilter. The sample air flow is directed through a concentrator, in which the major airflow is reduced to a one tenth of the original airflow and particles are concentrated.
The bioaerosol detector is equipped with secondary sample collection that can be initiated in the device by a biological alarm condition either automatically or manually in the user interface. The sample is collected onto a standard 37-mm bioaerosol collection filter inside a 37-mm filter cassette and after the collection, the sample can be retrieved from the filter with a rinsing protocol or the filter can be used e.g. for microscopic analysis.

    - A portable bioaerosol detector

The portable bioaerosol detector was built inside a Pelican case model 1560. It is designed to be deployable unit for biological threat detection and be used as a portable module with a local user interface or it can be applied in semi fixed installations with a system software. On top of the bioaerosol detector and a GPS location device, the portable unit can contain other measuring devices.
The portable unit can be used with external AC or DC power and also with internal battery. The device contains one lithium battery, which is automatically charging while the device is connected to AC or DC power.

1.3.2 WP2 Tests & Measurements

Task 2.1 Selection of model substances

The following subtasks are included in task 2.1:
- Selection of initial bio-agents from all classes (viruses, toxins, bacteria)
- Selection of more bio-agents if tests successful
- Determination of prominent substances (marker substances) occurring in selected bio-agents
- Determination of possible surrogates for bio-agents
- Determination of inactivation methods of bio-agents
- Inactivation of bio-agents
- Logistics for transportation of inactivated bio-agents / surrogates to partners

Initial pathogenic bio-agents have been selected:
- Bacteria: B. anthracis, F. tularensis "Bacterial part of the project"
- Viruses: Orthopoxviruses, Filoviruses "Viral part of the project"
- Toxins: Ricin and SEB "Toxin part of the project"

The project was started with selected bacteria ("Bacterial part of the project"), because the most complex spectra by GC-IMS could be expected for these agents. In a second phase, toxins and viruses (provided by internal and external collaborating partners) were included for further investigation.

For all classes of pathogenic bio-agents, surrogates were defined (see below) to test the proof of principle. The usage of surrogates was done at the initial step for each part of the project. The next step was to use inactivated material of the different pathogens. Chemical inactivation by using peracetic acid (PAA) or formaldehyde (FA) has been tested with the bacterial surrogates and confirmed to be safe. The pre-condition is that the inactivation methods preserve most of the characteristic markers for spectra analysis. So far PAA or FA inactivated bacterial spores or vegetative cells are offered in the catalogue. The inactivation step could make the analyses of bio-agents safer and simpler. Alternatively, the GC-IMS could be tested with native highly pathogenic bio-agents under BSL3-conditions, but current technical possibilities will not allow generation and testing of aerosols from these agents. It is expected that aerosols can be generated and tested from surrogates and inactivated bio-agents as well as bio-markers where indicated.
The whole approach will allow testing of proof of principle for the aerosol collecting unit of the instrument on one hand and the specific analysis of the bio-agents on the other hand.

Some of the agents belong to genera which include species and/or subspecies of different pathogenicity:

e. g. Bacillus anthracis
This bacterium belongs to the Bacillus cereus-group which members are very closely related but are of different virulence for humans:
- *B. cereus*, classified as biosafety level 2 (BSL2) organism
- *B. thuringiensis*, classified as BSL1, similar as

The "Bacterial part" regarding spores has been started with *B. thuringiensis* for safety reasons and the close relationship to *B. anthracis*. *B. anthracis* spores were inactivated for aerosol experiments or used for specific analyses under BSL3-conditions.

e. g. Francisella tularensis
The "Bacterial part" regarding vegetative Gram negative bacteria was started with Escherichia coli K12, a harmless bacterium (BSL1). This bacterium was used under the same conditions as spores of *B. thuringiensis.*

Orthopoxviruses
For known reasons, it will not be possible to work with variola poxvirus (not available). However, other poxviruses except Ectromelia and Camelpox are also pathogenic for humans and could serve as very realistic surrogates or even as potential bio-agents. All Orthopoxviruses show high genome homologies and are antigenically closely related.
The specific virus part of the project will utilise cowpox virus.

Filoviruses
The group of Filoviruses contains different serotypes, such as Marburg-virus and Ebola-like viruses.
As living viruses of this group require BSL4 conditions, only inactivated material can be handled, which will be purchased from an appropriate provider. Material from Marburg virus and one serotype of Ebola virus were planned be utilised later. As an RNA virus, murine norovirus (BSL1) will be used as surrogate for filoviruses.

Ricin
Ricin is a protein toxin. Ricinus communis-Agglutinin appears in the same plant as ricin, but has a much lower toxicity compared to ricin and will be used for the first investigations.
As surrogates for ricin albumin from bovine serum (BSA) and human serum (HSA), representing harmless proteins, are offered in the catalogue and will be tested first.

Staphylococcus enterotoxin B (SEB)
SEB is a globular superantigen. In case of SEB, BSA and HSA will serve as surrogates again.

Surrogates have been used for proof of principle. These surrogates mimic the bio-agents in their natural characteristics but are of low pathogenicity. For all classes of bio-agents, candidate surrogates have been selected (see table below).

Agent	Marker substance	Surrogate
B. anthracis	DPA, Anthrose, Toxins	*B. thuringiensis*, other bacilli
F. tularensis	LPS, recProtein	*F. novicida*, *E. coli* K12
Orthopoxvirus (Variola)	recProtein(matrix and membrane proteins)	Other non-pathogenic viruses
Filovirus	recProtein(matrix and membrane proteins)	Other non-pathogenic viruses
Ricin	-	Albumin, R. communis-Agglutinin
SEB	-	Albumin

Task 2.2: Proof of Concept

This task aimed at determining if it is possible to distinguish between hazardous and non-hazardous bio-agents.
The first objective was to verify the proof of concept and to conduct test measurements. This consisted in bringing out a test aerosol, testing the air sampler provided by CEA-Leti and obtaining spectra of the samples via pyrolysis and GC-IMS. The aerosol chamber available at the RKI was used to successfully produce defined aerosols of vegetative bacteria and spores. After a test campaign involving RKI and CEA-Leti, it was possible to obtain the best parameters for the air sampler and to collect bacterial spores from an aerosol inside the chamber with high efficiency. Afterwards these samples were subjected to pyrolysis followed by GC-IMS and obtained spectra were analysed.

RKI succeeded in comparing and telling apart spectra of *B. thuringiensis*, *B. subtilis* and *B. cereus*, thus demonstrating that even related species produce a unique spectrum in GC-IMS. They also managed to show that spectra of inactivated *B. thuringiensis* are identical to those of native B. thuringiensis spores collected via air sampling, thereby excluding the possibility that the collection method induces changes in the resulting spectra.

Experiments for this task also focused on finding a suitable inactivation method for all measured agents, in order to be able to handle them safely in a BSL2 laboratory. Further, it had to be investigated whether inactivation methods had an impact on obtained spectra and what method proved to be the most suitable.

- Viruses:

In case of viruses, inactivation by heat (60°C) and by UVC radiation was tested and both methods did not change obtained spectra. Heat inactivation was chosen as the method of choice for inactivation of measured viruses because of its easier practicability.

- Proteins:

Inactivation of proteins occurred by heating at 95°C for 20 minutes followed by centrifugation and cooling at 4°C. This procedure was tested with Bovine serum albumin (BSA) and Human serum albumin (HSA) and also in both cases no differences in the resulting spectra could be found, which makes it safe to assume that it is a suitable method for protein inactivation.

- Bacteria and bacterial spores:

Since bacterial spores are especially resistant against heat and UV-radiation, chemical inactivation had to be tested for these. Treatment with formaldehyde and peracetic acid was investigated and decision was made towards 1% peracetic acid, since formaldehyde proved too difficult to remove completely and measured spectra changed to some degree. The procedure was also applied in case of vegetative bacteria of risk group 3.

After extensive test measurements and comparing spectra of active and inactivated agents, decision was made towards using inactivated samples for building the database, since no differences whatsoever could be found regarding the spectra.

Task 2.3: Measurement of model substances

The most important task in this reporting period consisted in building a reliable spectra database by measuring as much target agents as possible and obtaining reproducible spectra, which could later be used for identification of target agents. For each group of agents (Viruses, vegetative bacteria, spores and toxins) at least one highly pathogenic member was investigated in addition to surrogates. Further, several hoax substances were measured as well, which are known to be commonly used to fake a bio terroristic attack or which might be present in monitored buildings:

Viruses:

- *Modified Vaccinia Ancara (MVA)*
- *Camelpox virus*
- *Murine Norovirus*

Vegetative bacteria:

- *Yersinia pestis*
- *Francisella tularensis holarctica*
- *Escherichia coli*

Bacterial spores:

- *Bacillus anthracis*
- *Bacillus thuringiensis*
- *Bacillus subtilis*

Toxins:

- *Ricin*
- *Bovine serum albumin (BSA)*
- *Human serum albumin (HSA)*

Hoax Substances:

- *Powdered sugar*
- *Flour*
- *Birch pollen*
- *Dust*

- *Yeast dough mix*

The database consists of over 500 spectra. Recorded peak patterns were reproducible and obtained peaks always exhibited the same drift times and retention times. This was checked by a self-learning neuronal network provided by ENIT, which analysed and compared peak patterns. According to this software, 94% of recorded spectra were identified correctly (see D2.31 Report on model substance measurements), which speaks highly for the reproducibility and effectiveness of the procedure.
Detection limits lie between 10^4 and 10^5 colony forming units per ml in case of vegetative bacteria and spores, at 10^4 plaque forming units per ml in case of viruses and between 500 ng and 1 µg per ml in case of proteins.

In the case of viruses, Filoviruses (Ebola, Marburg virus) were not included in the database, since obtaining inactivated samples proved to be difficult and very expensive. In addition for a long time it was not sure whether different viruses could be distinguished by the resulting spectra because of the culture medium present in the samples.

Task 2.4 Detection capability of the deployable IMS

The main advantage of a technology like the IMS lies of course in its speed when compared to laboratory detection methods. A time frame of three minutes from starting the pyrolysis until getting the results is not achievable with other methods in the laboratory except using Mass Spectrometry. However, IMS technology offers several advantages over the latter, as described in deliverable D2.42. Even lateral flow assays, which can be used on-site and are considered as very fast, take over 30 minutes to give a result and are only usable for some specific agents. Standard identification methods in the laboratory like ELISA, Polymerase Chain Reaction (PCR) and plate cultivation take several hours or days respectively.

Another big advantage of the IMS technology is that the sample does not have to be pre-treated chemically in some way, so it can be used like it is sampled by the particle collector and directly pyrolysed in normal environmental conditions.

Concerning detection limits, laboratory methods are more sensitive, since, judging from our experiments, the IMS needs between 100 and 1000 agents in the sample to yield a result, while it is possible to identify samples in the laboratory, especially with Real time PCR, that contain between 10 and 100 agents. However, it can be assumed that in case of an actual bio-terroristic attack there would be quite high concentrations of bio-agents in the sampled air volume, which might again give the IMS-technology an advantage because of its speed and on-site detection capabilities.

However, one of the criteria, the comparison of the rate of positive identification for bio-agents, could not be fully investigated, as the project partner in charge of developing the identification script for the recognition software (ENIT), did not deliver the expected script due to problems described in the management report. Thus, it was not possible to get an identification of the measured substances. The measurements with a self-learning software as described in D2.31 yielded a positive identification rate of 94%, which is a very good value for on-site detection. But the final statement on the identification capability of the IMS compared to the laboratory could not be fully achieved without a working identification script from ENIT.

Therefore, in the last period of the project, RKI focused its effort in testing the prototypes of the Bio-Protect device with all integrated components, performing test measurements with agents already in the database. These measurements were transferred to ENIT in order for them to improve the identification script for the recognition software on the IMS. It involved also providing ENIT with spectra of bio-agents mixed with potential interference material like dust or pollen.

1.3.3 WP3 Databasing & Analysis

This work package gathers all tasks for the development and customisation of the adequate pattern analysis software. Therefore the spectra gained in WP2 are analysed by the software and the resulting fingerprints of bio-agents are databased. Meanwhile possible interferences are also identified and added to the database.

Task 3.1: Coding of database and pattern analysis software

During the first period, recorded spectra were analysed by the evaluation software and classified according to the peak pattern. During the testing of the sample collector, pre-treatment and GC-IMS units at RKI, an unforeseen technical issue was identified. It was found that the quartz wool packing used in the pyrolyser module caused problems with memory effects and generation of contamination peaks. Further work was carried out at CTECH in order to identify an alternative matrix for the pyrolysis tube. The stainless steel cloth was found to give the best performance in terms of rapid heating and stability.

The following bio agents and substances were measured during the project:

- Gram positive bacteria

Bacillius thuringiensis, Bacillius subtilis, Bacillius cereus, Bacillius anthracis

- Gram negative bacteria

Escherichia coli, Yersinia mollaretii, Yersinia pestis, Live Vaccine Strain Francisella tularensis

- Virus

Modified Vaccinia Ancara, Camelpox virus, Murine Norovirus

- Toxine

Ricin, Bovine Serumalbumin, Human Serumalbumin

To create a database within the analysis software, the relevant specified features of a spectrum were needed. The relevant specified data are relative drift times and retention times.

A peak viewer tool to efficiently identify the relevant features of the substance was developed by Environics in order to speed-up the identification process and allow for a semi-automated analysis of the spectra. With the help of this tool, a database of prominent peaks for the investigated Bio-agents could be created. The peak viewer was improved by Environics until the end of the project to be able to easily identify the peaks and the pattern of each bio-agent.

The alpha versions then followed by the beta versions of the analysis software and the database were delivered.

- The database included over 500 spectra in total by 15 difference bio agents. The database was incorporated on the device and tests using the simulation software had been successful in showing that it is working as intended.
- The limits of the analysis software and its identification scripts were known:
    - The rule feature AND was implemented, but the IMS CPU was not powerful enough to compute the OR, NOR, etc. rules. It was decided to transfer the analysis software in the linux PC of the device to use the power of the PC CPU instead.
    - Due to this limitation, only the category of the bio-agent could be identify, not the bio-agent itself. This category identification rate was 80-90%.
- In order to be able to accelerate the coding of the identification scripts, two tools were developed:
    - Environics developed a spectra peak viewer in HTML5, which eases the work of ENIT in looking for relevant peaks of the spectra before integrating them in the identification scripts.
    - ENIT developed an IMS simulation tool which simulates an ingoing spectrum from the IMS. ENIT could then simulate measurements without having to pyrolyse actual bio agents, see if new set of rules works, easily change the rules and immediately check their effectiveness without starting a new measurement.

In parallel, the self-learning software was used to study the 500 spectra and revealed that it was possible to distinguish the 15 bio-agents from one another and identify them with a 94% rate of success. It was decided to study the possibility to integrate the self-learning software in the identification process in case the limit of the analysis software cannot be solved (figure 3.1), but also as a potential second confirmation step if the limit can be solved. ENIT needed to purchase the software and work with Environics to integrate it in the device (which required solving Window/Linux compatibility issues).

As a part of device's software development, the User Interface (UI), named also as Man Machine Interface (MMI), development has been carried out.
HTML5 was chosen for BioProtect because mobile access was required.
Two html5 software were created for using the Bio-Protect device:

- Simple UI, for basic user
- Normal UI, for advanced users

The Simple User Interface developed by LGI is meant for basic user, e.g. for fire fighter or soldier in the field. This user interface shows all necessary information at a glance, but no information which is not needed in field operations.
The normal UI is meant for advance user; by this user interface it is possible to control everything inside the device, like timings, settings of different sub-assemblies etc. Therefore, this level of user interface requires a password protection to prevent damages caused by untrained user.

The user-friendliness tests results reported by AAU (available in D4.31) regarding this simple UI are very positive. The improvement suggestions were taken into account to adjust the simple UI.
The simple UI was presented to the AUG in December 2013 during the 7th AUG meeting in Berlin and the AUG feedback was also very positive and taken into account.

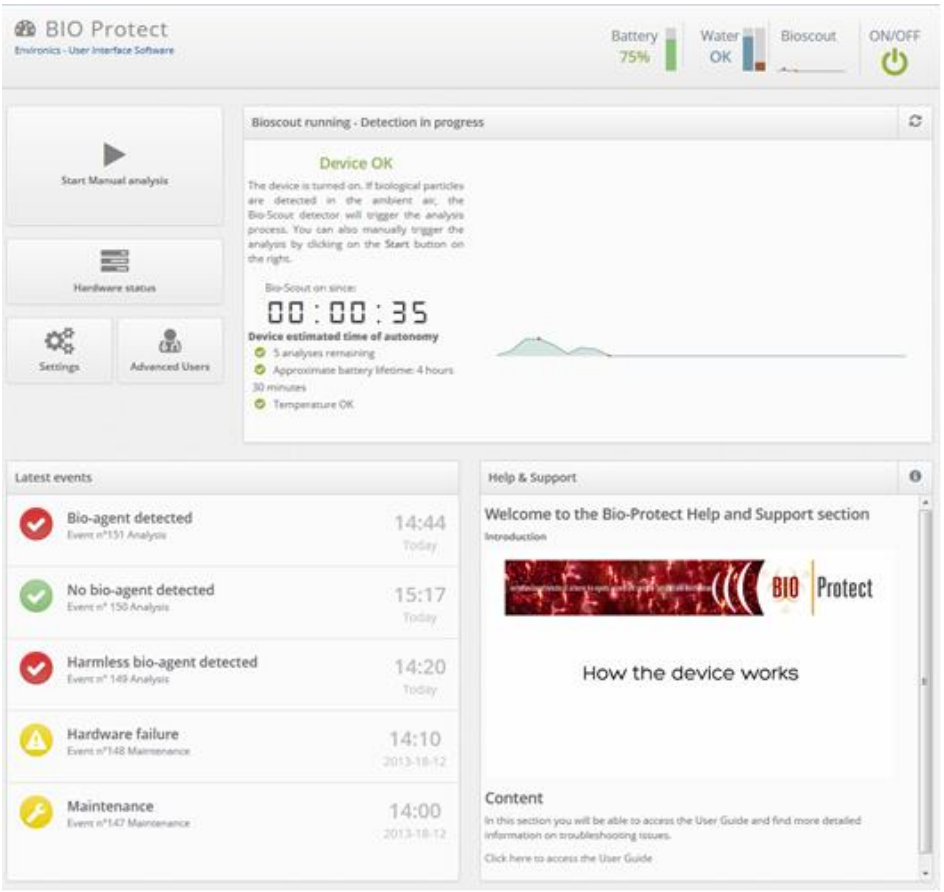


Figure 3.1: screen copy of the BIO-PROTECT User Interface

Task 3.2: Identification of interferences

Interference substances were determined by measurement aimed at collecting spectra of benign material and potential hoax. It was actually performed in WP2 by RKI and WP4 by AAU. RKI recorded spectra in its laboratory. Some materials were chosen and measured: powdered sugar, flour, birch pollen, dust, yeast

dough mix. It has been shown that at least these possible hoax materials show complex spectra but completely different to the tested bio agents. They also recorded spectra of interferences mixed with bio-agents (see D2.31).
Spectra of several interference substances were compared to spectra of all bio-agents in the database using the self-learning software and results indicated that they were clearly different. Judging from the look of spectra of interferences mixed with bio-agents recorded at the RKI, it can be assumed that good identification software for the GC-IMS would be able to identify the agent in question. Peaks derived from interference substances appear to be few and appear quite early in the spectrum and it is highly unlikely that they would mask peaks important for identification, since they would have to appear at exactly the same retention and relative drift times.

During the measurement campaign in Denmark regarding tests of benign interference compounds, a lot of spectra could be collected and gathered for analysis and integration by ENIT in the detection scripts. (see D4.31, interference test report).

1.3.4 WP4 Design, Field Testing & Certification

Device design, development, assembly and testing were carried out in this work package 4.

Task 4.1 Design

The task was initiated with the subtask *Evaluation of experience of test users*. The 1st Advisory User Group (AUG) meeting was held in Helsinki, Finland on 13 September 2011. In this meeting, the End User Requirements Questionnaire was introduced to the AUG members. Requirements, recommendations and advices were gathered from AUG using a web-based query tool. During the meeting it was decided together with project partners and AUG members that all the above-mentioned will seek for more possible end users and ask them to answer to the questionnaire. Results of this subtask were expected to be integrated with the subtask *Integration of end users' advices and specifications*.

The first step in the Design of the device was to gather as much as possible information from partners on their sub-assemblies (particle collector, Pre-treatment unit and GC-IMS). In order to be able to design the final device in terms of hardware, software and mechanical design, variety of interface information had to be gathered.
Once Environics received all subassemblies, the engineers were able to start their re-designing. The miniaturization aspect was taken into consideration during the design and integration phase.

Designing the Integrated Device started with 3D modelling of sub-assemblies in order to make them integrable into the Final device. At this point, it was noticed that sub-assemblies particularly the particle collector and Pre-Treatment unit needed total redesigning in order to integrate them into the design of the Device. Only GC-IMS from ENIT did not need major changes in the design, only some not necessarily needed components were removed to reduce weight. More details of the sub-assemblies' redesigning can be found in the D4.11 "Design of the Device".

Furthermore, sub-assemblies had to be integrated and joined together so that the system would be automatically functioning. Linking together the Particle collector and the Pre-Treatment Unit turned out to be a challenging task. This is not only a connection between these two parts, but it had to be capable of transferring automatically 15 ml of aqueous sample from the Particle collector, and from these 15 ml to be capable of taking 10 µl sample and inject it into the Pre-Treatment unit. Fortunately, Environics invented an innovative method for carrying out this task with a system including special micro pumps and valves.

Based on the redesigned subassemblies and developed components, the overall mechanics design was created. Details of this are also described in the D4.11, and below is presented a figure of the overall design of the Device.

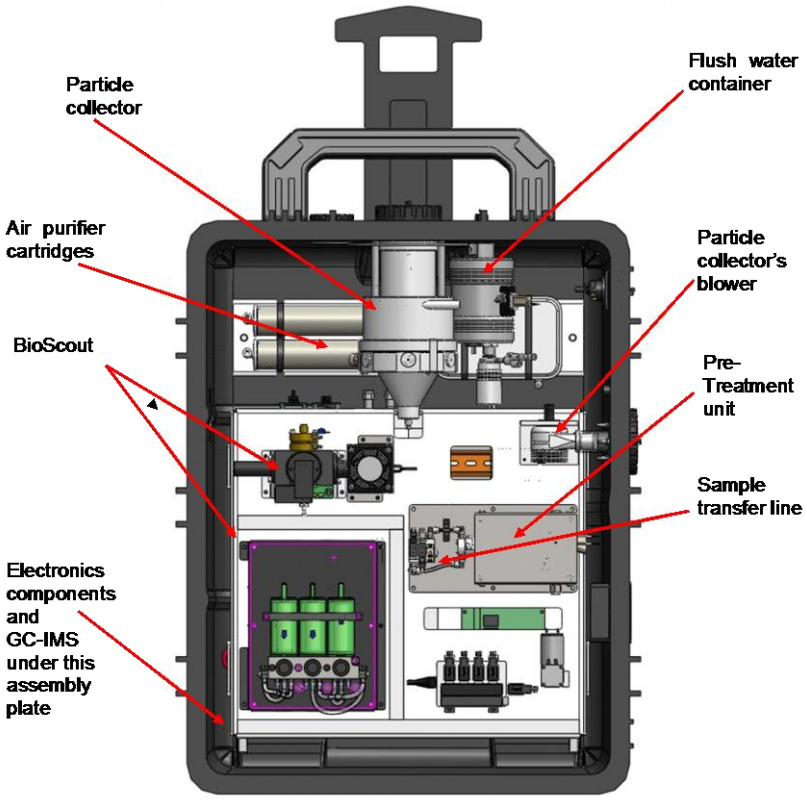


Figure 4.1 Component/part layout of the BioProtect Device

The final device has to be fully autonomous and therefore overall hardware (HW) and control electronics had to be developed in order to control everything in the device. Moreover, existing sub-assemblies' electronics needed total redesigning in order to integrate them into the final device as well as to miniaturize them. As a result of this development work an embedded control board was created, to control most of the processes in the BioProtect Device. Besides the Hardware designing, a combined battery pack and AC power were also developed. More details of Hardware design and development can be found in the deliverable D4.11.

A lot of work and efforts were also allocated for developing the software (SW) of the Device. The software can be divided into four layers:

- *Hardware layer*, embedded software in each sub instrument
- *Hardware communication layer*, for each sub instrument there is daemon program (python script) handling communication in between serial virtual device and MySQL. This daemon reads settings and setpoints from MySQL, write settings and start reading measurement data from sub instrument.
- *MySQL*, All log data and device configuration values are stored on MySQL tables. MySQL server handles also data sharing problem; how multiple data consumers can access same resources. At default configuration MySQL server is located on embedded linux PC.
- *User Interface*. Default user interface is HTML5. HTML and .PHP files are stored on internal web server by default.

Software coding is a continuous process and therefore software coding, especially the User Interface coding was continued until the end of the project.

Task 4.2 Miniaturization and assembly

The miniaturization of components, subassemblies and the overall device was taken into account during the design and integration phase. For example the particle collector and the pre-treatment unit are almost totally redesigned for miniaturisation purposes and to make their integration possible into this kind of mobile detector device. Electronics which were laboratory setup-style boxes were redesigned and integrated to minimised

electronics components. However, some components e.g. the GC-IMS were not miniaturised. The GC-IMS is a complicated and very sensitive analysis instrument and therefore removing it from its original housing was not reasonable. Thus it was left as it is. Because the GC-IMS is relatively large, a 19 inch rack model, it set boundary conditions for selecting the housing (the case) for the Bio-Protect integrated device.
It was decided that two units of the integrated devices will be assembled. The first device was assembled during this second reporting period. The second unit was assembled in the third period, so that minor changes in design and components could be implemented. For example during the second period of the project, ENIT built a second GC -IMS. This second device is a copy of the first one but the unused parts were eliminated. In summary the second device has less weight. The 2nd assembled device is shown in the figure below.

Figure 4.2 The second BioProtect Device with battery pack and Panasonic TouchPad

RKI was able to measure numerous bio agents with the first device and after adjustment of the device parameters device, good spectra were obtained with several agents.
The second device was directly sent to Techonin (Czech Republic) for field tests, after functionality testing with *B. thuringiensis* performed at Environics.

Task 4.3 Field tests and simulations

The field test campaign in Techonin, Czech Republic took place on 7th-10th October 2013. The AUG members also contributed to its organisation, planning and implementation. Mr. Alan Gavel (Fire Rescue Service DG, Czech Republic) organized an optimal training ground with excellent facilities and environment for the field tests, which included transport logistics. The Czech team was composed of 4 members from CBRN reconnaissance teams of the Population Protection Institute (Fire Rescue Service DG) and regional Fire Rescue Service detection laboratories. The German team was composed of 3 members from the Analytical Task Force (a CBRN reconnaissance team from the Mannheim Fire Brigade).
Both teams tested i) how to handle the Device transportation using stairs, and also ii) the operation mode of the Device. They also provided a report on the evaluation of the Device and their feedback was collected through interviews by AAU.

A report of this test campaign was written and is available in the annex 3 of *D4.31 Results of tests and simulations.* At first the user friendliness / usability testing was carried out by the German (ATF Mannheim) and Czech first responders teams (see figure 4.3) and this testing was followed by the bio agent tests which were carried out first in BSL4 (Bio Safety Level 4) hospital. Useful feedback from the end users was collected during and after the usability testing.

Figure 4.3 German team (left) during the usability testing and Czech team (right) after the trial

Another testing campaign was carried out in Denmark by the Building Research Institute at the Aalborg University (AAU). The purpose was to carry out indoor measurements with different possibly interfering aerosols. Another part of this assignment was user friendliness testing. AAU wrote test reports of this test campaign which are also included in the annexes of *D4.31 Results of tests and simulations, which are* entitled *"Test report on interferences compounds"* as well as *"Report of Field Test using the second generation user-interface and CBRN and FM users".*

Task 4.4 Validation and certification

The development of the Bio-Protect Device reached a prototype level TRL 7, deviating from the initial plan to have a market version of the device ready at the end of the project. However, actions were taken by RKI in order to initiate national certification in Germany and at the same time to introduce the project, device and results.

The RKI presented BIO-PROTECT as well as its results and progress to a group of experts of the Wehrwissenschaftliches Institut für Schutztechnologien (WIS, Military Scientific Institute for protection technologies) of the German army by the city of Munster. Since the prototype was not completely functional, and did not include an identification script for the IMS-software and thereby could not recognize specific bio-agents, obtaining a certification was not possible at this stage.
However, the WIS offered a theoretical evaluation of the technical components as well as the gained spectra and the planned approach for identification. Further, they showed interest in testing the prototype itself.

Following the achievements performed in the project, the deliverable D4.41 Final Market version of device describes the status of the device at the end of the project and identifies further developments needed in order to reach a marketable level with the device.

1.4 Potential Impact, main dissemination activities and exploitation of results

1.4.1 Potential Impact

The successful development of an autonomous sensing system for detection and identification of biological agents within this project was expected. The system is complex since it incorporates functions of sample collection, detection, analysis, signal processing and readout on the instrument as it is meant to be mobile. It targeted microorganisms and viruses as well as biological toxins which are capable of severely taking ill or killing mammals. These are agents for potential application in terrorist attacks (e.g. "dirty dozen" agents) and accidentally released microorganisms and toxins.

The resulting system was expected to detect possible biological threats automatically by first responders who will then trigger the actual measurement. The identification systems aimed at identifying the pretreated bio-agent by means of a pattern analysis and provide the operator with the kind of threat. It was anticipated that the resulting device would not only be able to indicate the bio-agent class, but the actual species. Thus in most situations it would give enough information to biological untrained security personnel, in order to trigger a response plan. For the other situations the measured data could be stored and can be accessed by trained personnel (either via cable or a wireless network). Of course the device does not circumvent the need of HAZMAT teams or proper laboratory identification of the bio-agent. But its identification can indicate the kind of counter measures to be taken as well as indicating the medical treatment for possible victims. Thus it will provide the medical staff with reliable information with what they have to deal with. This in turn will provide affected persons with the best possible medical treatment at once.

The device combines the **detection** and **identification** of bio aerosols. It continuously measures air and if sudden change in particle amount is noticed, the trigger unit triggers the particle collector. The particles are rinsed from collector and a small precise amount is fed with innovative sample transfer line into the Pre-Treatment unit. In the pre-treatment unit sample is first dehumidified and then pyrolyzed. Gases produced in pyrolysis process are fed to the GC-IMS where the analysis of gases is done.

Advantages for users:

- Detection and identification with one device
- Separation between bacteria, viruses and toxins: superior tool in case of suspected material in air.
- Fast and reliable result, based on which can be initiated countermeasures
- No reagents needed; thus lower operating costs
- Secondary sample collection available
- Upgradable Database
- Customizable and Easy-to-use web based user interface
- Networkability via LAN/WLAN

This device provides security personnel with a reliable tool to take fast, effective countermeasures when confronted with biological threats. Pattern analysis software has been developed for the interpretation of acquired spectra, identifying bio-agents and distinguishing them from background bacteria. Thus a database of several model-agents including bacteria, spores, toxins and viruses has been generated.

As the Device was not tested in all possible environments during the project because of limited time in the project, it was noticed while assembling, using and testing the device that further development of some parts and components are needed to improve the device and reach marketable level. In general the device must be developed to be more robust and reliable.

Similar technologies and products are commercially available and are presented in deliverable D5.23- Market Study. The market potential for biological detection and identification devices suitable for fixed CBRN monitoring systems for building and area protection is estimated to range in the amounts of 20 – 40 units annually in the selected market region.

- **Societal impact**

The device could be a powerful tool in fast detecting and identifying bio-agents. Its readouts would provide viable information on which countermeasures to take. Even if the device is not sure of the identification, the data can be accessed and evaluated by experts. Hence the security personnel can at least start generic bio-safety actions. Assuming a plan of action is available security personnel with this knowledge in mind are sensing that they can do something valuable. This in turn will calm them down, and their reaction will reflect onto the affected people, thus lowering the effects of panic and finally reduce victim numbers.
This will create a sense of security and the certainty: “There is immediate help, even if something happens.” This sense of security will relax people working in “endangered” areas as well as their families and thus improve their productive output.

1.4.2 Main dissemination activities and Exploitation of results

- **Dissemination**

The main communication and dissemination actions of the project were as follows:

- The Public website www.fp7-bioprotect.eu developed during the first two periods was updated and maintained during the third period.
- Several Bio-Protect presentations were performed at European or national events:
  - EU Workshop
    - Joint CBRNE symposium (EC-DECOTESSC1-CBRNEmap): Brussels, June 2011: active participation by LGI
    - Stand Off Bio-Detection SoBID workshop, European Defence Agency, Brussels, 06, 07 May 2013: Presentation of BIO-PROTECT by LGI
    - Final Workshop of the project organised in Paris on 23 January 2014 with the support of HCFDC: French High Committee for Civil Defence, with another European project FP7 - PRACTICE. Presentations were made by all partners of Bio-Protect.
    - EDEN Workshop Brussels, 29 January 2014: EDEN is an FP7 project which constitutes a catalogue of CBRNe technologies at European scale; as a result of the participation in this workshop, Bio-Protect has been included in this catalogue, expected to become the European reference.

  - Participation in events
    - CBRNE events
      - Colloque "CBRN and critical infrastructures" organised by HCFDC, Paris, 4 April 2012: representation of BIO-PROTECT at Q&A session by the Coordinator
      - CBRNe Europe 2012 Light, The Hague, 21-22 May 2012: Presentation of BIO-PROTECT by the Coordinator
      - NBC2012 – 8th Symposium on CBRNE Threats (Finland), Turku, June 2012: paper + poster by Environics, participation of LGI
      - CBRNe Convergence 2013 San Diego, USA 29-31 October 2013: LGI presented the project poster.
    - Other related events
      - Bio-Security Symposium, Berlin, 17-19 April 2012: RKI stand with possibility to display BIO-PROTECT material
      - International Crime Science Conference, British Library, London, 4 July 2012: Presentation of BIO-PROTECT by the Coordinator
      - Milipol 2013 Paris, France, 19-22 November 2013: The project Coordinator participated to an online Talk-Show organised by HCFDC and presented the Bio-Protect project.

- The BIO-PROTECT User Community portal was developed and released by LGI in January 2014: it includes tutorial videos and a User Guide.
- A video on the Bio-Protect project was prepared by LGI with the participation of all partners. This video presents the Bio-Protect project, its partners and its device. It was shown during the final workshop in Paris. Link to the video: http://www.youtube.com/watch?v=1mXzK5-xet0
- An updated poster was prepared and presented at the CBRNe World Conference in San Diego.
- Flyers on the project were designed and distributed at the Final Workshop in Paris.

- **Exploitation**

Potential end-users include:

- Public buildings (hospitals, hotels, administrations, police stations, museums, shopping centres, universities etc.),
- Industrial plants which are potential targets to bio-terror (food industry)
- Selected public transport (aircrafts, trains, etc.)
- Fire and Rescue Departments, Health Emergency Situations Centres and VIP Protection Department under the Ministry of the Interior or similar
- Hospitals and biotechnology industries, for controlling potential accidental release of bio-agents
- Laboratories
- Military infrastructures and military vehicles
- Other similar facilities

This section below identifies and describes results arising from the project that have commercial relevance.
List of results

Result 1. Bio-Protect device

- Prototype n. 1
- Prototype n. 2

Results 2. Bio-Protect subassemblies/subsystems

- Trigger unit (Bio Scout)
- Air sampler
- Pyrolyser
- Gas Chromatograph coupled to Ion Mobility Spectrometer (GC-IMS)
- Operational software and Database

Result 3. On-line portal for the Bio-Protect User Community

- Portal accessible in the first stage only to Bio-protect consortium partners

Step-by-step evolution to share information through the portal with end-user group and testing partners external to the project

1.5 Project information

Website address: **www.fp7-bioprotect.eu**

Project type: Collaborative Project (Small- or Medium-Scaled Focused Research Project)
Project start date: 01/06/2010 **Duration**: 44 months
Total budget: EUR 3,955,204 **EC contribution**: EUR 3,125,577

Partners:

1	LGI Consulting	LGI	France
3	C-Tech Innovation Ltd	CTECH	United Kingdom
4	Environics Oy	Environics	Finland
5	Commissariat à l'Energie Atomique	CEA	France
7	Robert-Koch Institut	RKI	Germany

8	University of Aalborg	AAU	Denmark
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